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PROCESS DESIGN OF FUEL SYSTEMS

(PROJECT STANDARDS AND SPECIFICATIONS)

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SCOPE

This Project Standards and Specifications specify the minimum requirement for process design of fuel systems used in OGP industries. Major design parameters and guidelines for process design of fuel systems.

This Standard covers gaseous and liquid fuel systems, and shall not be applied for solid fuel system.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. **BSI (BRITISH STANDARDS INSTITUTION)**

   BS 5351, "Specification for Steel Ball Valves for the Petroleum, Petrochemical and Allied Industries", 1986
   BS 6843, "Classification of Petroleum Fuels", 1988

2. **API (AMERICAN PETROLEUM INSTITUTE)**

   API-RP-550 "Manual on Installation of Refinery Instruments and Control Systems", 4th. Ed., July 1985
   API Standard 616: ”Gas Turbines for the Petroleum , Chemical and Gas Industry Services “, ED.1998

DEFINITIONS AND TERMINOLOGY

Bunker "C" Fuel Oil - A heavy residual Fuel oil used by ships, industry, and for large-scale heating installations. In industry, it is often referred to as Grade No. 6 Fuel Oil.

Fuel Gas - Any gas used for heating.

Fuel Oil - Any liquid or liquefiable petroleum product burned for the generation of heat in a furnace or firebox, or for the generation of power in an engine, exclusive

of oils with flash point below 38°C (tag closedcup tester) and oils burned in cotton-or-wool-wick burners.

Heating Value of a Fuel - The caloric, thermal, or heating value of a fuel is the total amount of heat generated by the complete combustion of a unit quantity of fuel, expressed as kJ/kg for liquid fuels and MJ/Nm^3 for gas fuels.

Liquefied Petroleum Gas (LPG) - Light hydrocarbon material, gaseous at atmospheric temperature and pressure, held in the liquid state by pressure to facilitate storage, transport, handling. Commercial liquefied petroleum gas consists of propane, butane, or mixture thereof.

Manufactured Gas - All gases made artificially or as by-products, as distinguished from natural gas; applied particularly to a utility sendout.

Mazut - A Russian name for distillation residues used largely as fuel oil; also spelled "masut" or "mazout".

Natural Gas - Naturally occuring mixtures of hydrocarbon gases and vapors, the more important of which are methane, ethane, propane, butane, pentane, and hexane.

Purging - The displacement of one material with another in process equipment; frequently, displacement of hydrocarbon vapor with steam or inert gas.

Refinery Gas - Any form or mixture of gas gathered in refinery from the various Units.

Residual Fuel Oil - Topped crude oil or viscous residuum in refinery operations.

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
AGA	American Gas Association
API	American Petroleum Institute
BSI	British Standards Institution
CCR	Continuous Catalyst Regeneration
EPM	Engineering Practice Manual
FCC	Fluidized Catalytic Cracking
HFO	Heavy Fuel Oil

ISO	International Organization for Standardization
LC	Level Controller
LDF	Light Distillate Fuel
LI	Level Indicator
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
PIC	Pressure Indicator Controller
Sp Gr	Specific Gravity (Relative Density)
THI	Temperature High Indicator.

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

FUEL SUPPLYING SYSTEMS

General

1. Fuel shall be used to provide heat for power generation, steam production and process requirements.
2. Fuel system shall include facilities for collection, preparation, and distribution of fuel to users.
3. Alternative fuels (as required) should be made available at all consuming points. The commonly used ones are liquid fuel and gas fuel.
4. On liquid fuel supplies at least one pump and its standby should be steam driven or available reliable other power sources. Standby pumping units shall be arranged for instantaneous start-up on the failure of the operating unit.

Fuel Selection

1. The selection of fuels used in the system shall be based on the cost, availability, dependability of supply, convenience of use and storage, and environmental regulations.
2. Materials Produced in the Plant which cannot be sold the least monetary value should possibly be used as fuel.
3. Diverted to plant fuel oil system include visbreaker tar, Lube extracts ,Waxes and atmospheric residue.

4. Gaseous materials diverted to refinery fuel are those which cannot be processed to salable products economically, and frequently include, H_2, CH_4, H_2S* and C_2H_6 and shall be contained essentially of CH_4 and/or C2H6 (see Appendix A item 1).

   Note:

   * H_2S content of fuel gas main header should be complied with local regulations and subject to Company's approval.

5. Provision(s) shall be made for using the liquefied petroleum gas (LPG) and/or natural gas to supplement the gaseous fuel.

Liquid Fuel

1. General
   a. The ultimate aim in liquid fuel supply system design shall be to ensure that the supply of suitable fuel to each fired heater/furnace will not fluctuate with load changes.
   b. All liquid fuels lighter than fuel oil should be filtered through mesh of about 0.3 mm aperture.
2. Fuel oil system
   a. A typical system includes tankage from which the circulation pumps take suction, pumping the fuel oil through the heaters and strainers to the main circulation system. This serves all Units that are potential users of fuel oil and returns to the tank, through a back pressure controller.
   b. The system should be designed to supply fuel oil to the furnaces at constant pressure and at the required viscosity. The required pressure depends on the type of burners used in the furnaces. The viscosity requirement should be met by means of temperature control.
   c. The system shall be designed so that from the fuel oil tanks, one supply and return header serves the processing Units while a separate supply and return header serves the boiler plant.
   d. In the system design, particular attention should be paid to the following:
      i) Circulation Pumps

      To provide a reliable supply of fuel oil at least three pumps should be used. Typically, at least one pump should be turbine driven (upon availability of steam) and the others motor driven.

Automatic cut-in of the standby pump should be provided on low pressure in the fuel system. Loss of one pump may nevertheless result in a considerable pressure transient in the fuel oil supply system, which may cause furnaces to trip. By having three pumps each of about 70% capacity this effect is reduced considerably.

ii) Piping System

In the case of heavy fuel oil, measures should be taken to prevent plugging of lines. These may include heat tracing, insulation, and a separate flushing oil system (low pour point fuel). The flushing oil system will facilitate furnace starting up and shutting down operations and flushing out of lines, filters and fuel oil heaters.

iii) Strainers

To prevent plugging of the burners, parallel strainers should be installed in the discharge and suction of fuel oil distribution pumps, with the mesh sizes of 0.75 and 1.5 mm respectively (Unless otherwise specified by the pump manufacturer).

iv) Instrumentation

The system should be equipped with a low pressure alarm for supply header, located in each control house.

e. Heaters on each fuel oil tank shall be able to keep the content at about 65°C. This temperature should be limited to a maximum of 115°C to minimize possibility of boil-over due to vaporization of water in tanks. The fuel oil supply header temperature shall be maintained at a temperature consistent with burner supply viscosity requirements.

f. To obtain the required fuel oil supply temperature adequate heat exchangers (fuel oil heaters) heated by 2000 kPa (g) [20 bar (g)] medium pressure steam shall be provided. These heaters shall be installed in parallel arrangement, and all will be required to be in service when maximum fuel oil consumption is experienced.

g. Fuel oil supply temperature shall be regulated by controlling steam flow to the heaters.

h. By using fuel oil at each Unit, provision shall be made for a fuel oil return line with block valve.

i. A fuel oil return meter shall be provided on each Unit that consumes fuel oil. 6.3.2.10 The recirculating fuel oil shall be returned at substantially temperature difference with respect to the exchanger effluent, it may be

directed back to the tank through the small vapor disengaging drum. Smoother operation will result, if it shall be always directed into the pump suction while the tanks are only heated to about 65°C.

j. The fuel oil system shall be designed such that at least 2 parts shall be supplied to the heater, one part burned, and one part returned. Unless otherwise specified the size of the return header shall be the same as the size of the supply header.

k. Separate nozzles should be provided on storage tanks for make-up of fuel oil, recirculation, and withdrawal of oil. The arrangement of nozzles should minimize short circuiting of recirculated oil.

l. Fuel oil supply header shall be controlled at a minimum pressure of 1000 kPa (g) [10 bar(g)], unless otherwise is specified for process requirements.

m. Relief valves shall be located on the discharge of the pumps and on the fuel oil heaters. Relief valve discharges should be piped back to the fuel oil storage tank.

n. Typical refinery fuel oil system is shown in Fig. B.1 in Appendix B.

3. Refinery gasoline fuel

Refinery gasoline fuel (visbreaker gasoline) may be considered as an alternative liquid fuel in steam boilers.

Gasoline fuel system shall have its own facilities for storage, pumping and filters.

To accommodate variations in gasoline fuel demand, pressure control spillbacks shall be considered to allow excess fuel returned to the storage tanks as required.

Following instruments shall be provided in boiler house control room:

- Visbreaker gasoline storage tank low level alarm.
- Visbreaker gasoline supply header, pressure indication and low pressure alarm.

Gaseous Fuel

General

1. The fuel gas supply system shall be designed to provide the consumers with liquid-free gas at constant pressure [about 350 kPa (g) or 3.5 bar (g)] and reasonably constant heating value.

2. The system shall include, collecting piping, mixing drum controls, and distribution piping. A typical refinery fuel gas system is shown in Fig. B.2 in Appendix B.
3. All fuel gas stream shall be routed to mixing drum where entrained liquid is separated from the gas and where good mixing is ensured before distribution.
4. Location of fuel gas mixing drum should minimize collection and distribution piping.
5. Liquid from the knockout drum and mixing drum shall be drained to a closed recovery system or flare header.
6. The main source of fuel gas shall be the gas produced in process Units and treated in the treating unit (if necessary). In order to enable the balancing of gas production and gas consumption, necessary provisions for installation of LPG vaporizer and natural gas supplying systems to fuel gas mixing drum shall be considered.
7. If main fuel gas header pressure drops to its preset value, LPG and/or natural gas shall be used to supplement the make-up gas.
8. A liquid knockout drum near the gas consuming furnace (or group of furnaces) shall be provided to prevent liquid from entering the burners.
9. The mains and all fuel gas lines shall be steam traced and insulated to hold a temperature of at least 49°C to prevent condensation and hydrate formation.
10. To counteract the tendency of butane to recondense in mixing drum, a steam coil in its base shall be provided. Provision for installation of relief valve to flare header shall also be considered.
11. The fuel gas supply system should be equipped with enough controls and alarms, such as low system pressure and high knockout drum liquid level alarms, to assure a safe fuel gas supply.
12. The pressure controlling system shall be provided to fuel gas mixing drum, which actuates from fuel gas main header and responses to steam control valve of LPG vaporizer and/or natural gas control valve to supply required pressure.
13. In the event of high pressure in mixing drum (abnormal condition), the excess gas shall be released to the flare on pressure control.
14. Alarms should be fitted to the pilot gas system to warn of low pressure /low flow.

LPG Vaporizer

General

1. Liquefied petroleum gases (LPG) shall be used as a fuel in gaseous form. Vaporizer system shall be provided for this purpose.
2. The system shall consist of the following:
   a. one LPG surge drum;
   b. two LPG fuel pumps, one in operation (motor driven) and one stand-by (turbine driven);
   c. one LPG vaporizer;
   d. all necessary controllers.
3. Various streams of LPG and butane shall be received in the LPG surge drum and will be pumped into the fuel gas vaporizer.
4. Pressure in the LPG surge drum should be uncontrolled and will fluctuate with composition and temperature.
5. Level in LPG surge drum should be controlled. Surge drum level shall be recorded and provisions for high and low liquid level alarms shall be installed.
6. Provision shall be made to cut incoming LPG streams to the surge drum and pump LPG surge drum, provision shall be made to pump LPG directly into the flare header(if necessary).*

   Note:

   *This situation may occur temporarily due to low gas consumption.
7. LPG surge drum. Provision shall be made to cut incoming LPG streams to the surge drum and pump LPG directly into the flare header(if necessary).
8. By-pass line for LPG fuel pumps shall be provided to transfer LPG from LPG surge drum to fuel gas vaporizer, in the event of high pressure in LPG surge drum.
9. LPG fuel pumps shall have minimum flow by-pass line to protect them at times of low consumption of LPG.

   Instrumentation shall be provided to start automatically spare LPG fuel pump in case of failure of the main pump.
10. Size of the vaporizer, i.e., heat exchanger required depends upon the following factors:
    a. maximum gas demand;

b. size and location of LPG surge drum;

c. minimum amount of gas carried in LPG surge drum;

d. climatic conditions;

e. gas pressure to be supplied by plant.

11. Location of the safety valve on the fuel gas vaporizer shall be in vapor portion of that to avoid the problem of having liquid LPG going into the flare header.

12. A vaporizer should be equipped with an automatic means of preventing liquid passing from vaporizer to gas discharge piping. Normally this shall be done by a liquid level controller and positive shut-off liquid inlet line or by a temperature control unit for shutting-off the liquid line at low temperature conditions within vaporizer.

Minimum Data Required for Basic Design

Following data shall be provided as a minimum requirement for basic design calculation of liquid fuel to be used for normal operation or alternative operations, including startup.

- Net Heating Value, in (kJ/kg)
- Gross Heating Value, in (kJ/kg)
- Sulfur, in mass, in (mg/kg)
- Vanadium, in mass, in (mg/kg)
- Sodium, in mass, in (mg/kg)
- Nickel, in mass, in (mg/kg)
- Iron,in mass, in (mg/kg)
- Conradson Carbon, in (mass %)
- Ash, in (mass %)
- Other Impurities in (mass %) or mass, (mg/kg)
- °API
- Viscosity: dynamic in (Pa.s) at 100°C or at specified temperature °C
- Vapor pressure, in (Pa) at specified temperature °C
- Flash Point, in (°C)
- Pour Point, in (°C)
- Supply header operating pressure, in [kPa (g)] or [bar (g)] (max., normal, min.),

- Return header operating pressure, in [kPa (g)] or [bar (g)] (max., normal, Min.),
- Supply header operating temperature, in (°C) (max., normal, min.),
- System mechanical design pressure & temperature, in [kPa- (bar)] & °C.

Following data shall be provided as a minimum requirement for basic design calculation of fuel gas to be used for normal operation and for alternate operations, including startup, if pilot gas is not supplied from the fuel gas header, its properties shall be provided.

- Relative density (specific gravity) at 15°C
- Net heating value, in (MJ/Nm^3) or [kJ/kg]
- Gross heating value, in (MJ/Nm^3) or [kJ/kg]
- Flowing temperature, in (°C) (max., normal, min.)
- Header operating pressure, in [kPa (g)] or [bar (g)] (max., normal, min.)
- System mechanical design pressure & temperature, in [k Pa (g)] or [bar (g)] & °C
- Total sulfur, in mass, (mg/kg)
- Chloride, in mass, (mg/kg)
- Other impurities, in (volume %) or mass, (mg/kg)
- Flow rate available, in (Nm^3/h).

FIRED HEATERS FUEL SYSTEM-DESIGN

General

The fuel system shall be in accordance with the following requirements.

1. The pilot gas, where practicable, shall be taken from a sweet gas supply, independent of the main burner gas, or from a separate off-take on the fuel gas main, with its own block valve and spade-off position. Unless otherwise approved by Company, the pilot gas pressure shall be controlled at 35 kPa (0.35 bar) and the pressure regulating valve shall be the self-operating type.
2. Fuel manifolds around heaters shall be sized such that the maximum pressure difference between individual burner off-takes shall not exceed 2% of the manifold pressure at any time. In addition, account shall be taken of the effect to individual burner pipework sizes and arrangements on the distribution of fuel flow to each burner.